Nanoklystron: A Monolithic Tube Approach to THz Power Generation

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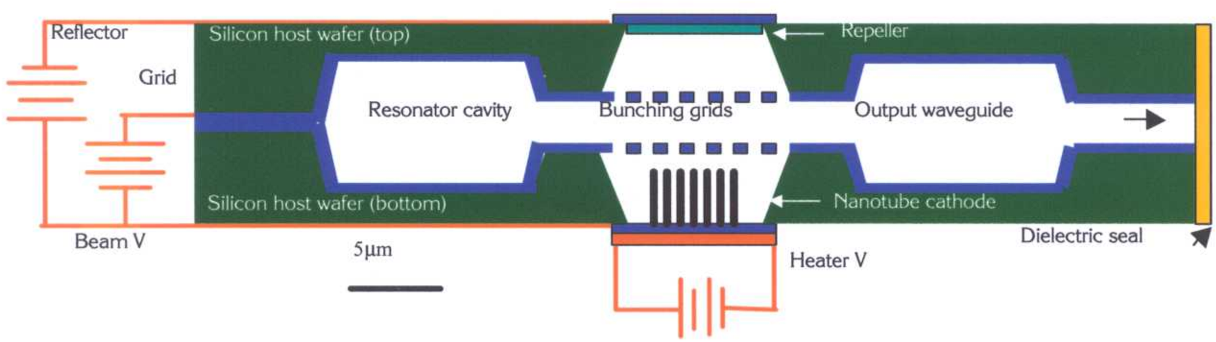
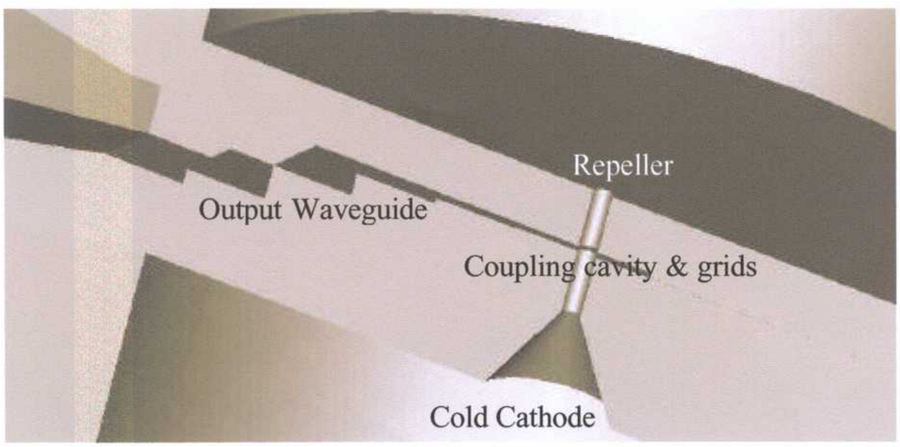
ABSTRACT

The authors propose a new approach to THz power generation: the nanoklystron. Utilizing monolithic silicon micromachining techniques and/or LIGA processing, the design and fabrication of a THz vacuum tube reflex klystron source is described. The nanoklystron employs a separately fabricated cathode structure composed of densely packed carbon nanotube field emitters and an add-in repeller. The nanotube cathode is expected to increase the current density, extend the cathode life and decrease the required oscillation voltage to values below 100V. The excitation cavity is based on ridged-waveguide and differs from the conventional cylindrical re-entránt structures found in lower frequency klystrons. A quasi-static field analysis of the cavity and output coupling structure show excellent control of the quality factor and desired field distribution. Output power is expected to occur through an iris coupled matched rectangular waveguide and integrated pyramidal feed horn. The entire circuit is designed so as to be formed monolithically either from two thermocompression bonded silicon wafers or in one piece using novel LIGA and electroforming techniques. To expedite prototyping a 600 GHz mechanically machined structure has been designed and is in fabrication. A complete numeric analysis of the nanoklystron circuit, including the electron beam dynamics has just gotten underway. Separate evaluation of the nanotube cathodes is also ongoing. The authors will describe the progress to date as well as plans for the immediate implementation and testing of nanoklystron prototypes at 640 and 1250 GHz.



Schematic of nanoklystron showing electronic elements and cavity.



Cross section of nanoklystron cavity showing output structure, cold cathode and repeller positions. The circuit is composed of two silicon wafers which are thermo - compression bonded to one another and vacuum sealed. A configuration using a single LIGA mandrel is also being designed. A 640 GHz all metal precision machined version is currently being fabricated.